Economics of Soil Moisture Sensors

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June 6, 2018
MOISST Workshop

Outline

- Why the economic assessment of soil moisture sensors (SMS)?
- An example of economic assessment
- Research topics

The economic value of soil moisture sensors (SMS)

Key points:

- Producers are unlikely to conserve water at the expense of profit (Some agricultural producers care about water conservation, but not as much as profit)
- If the technology is not profitable, they would not use it unless its cost is covered (cost share programs)
- You can make the method as fancy as you would like, but it has to be cheap enough to implement for producers (not us researchers)

Definition: Economic value of a (system of) technology

Economic value = Profit (after) - Profit (before)

$$Profit(\text{after}) = Revenue(\text{after}) - Cost(\text{after})$$
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Partial budget analysis

Look at the changes in revenue and cost before and after the adoption of the technology

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How can reliable estimates of the economic value of SMS help us?

- Agricultural producers
- Technology developers
- Policy makers (e.g., NRDs)

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Producers

Estimates of the economic value of SMS help producers when they decide whether to adopt the technology or not. However, its usefulness does not end there.

How can the economic assessment of technology help us?

Technology developers

What the price of technology has to be for it to be widely adopted?

- Suppose that SMS alone can save 2 inches on a 130-acre field, where the pumping cost is $\$3$/acre-inch
- Then, the annualized cost of SMS cannot exceed $\$780$ (target cost)

How can the economic assessment of technology help us?

Policy makers (e.g., NRDs)

- What is the best cost share amount?
  - Their budgets are limited $\Rightarrow$ Too high cost share amounts would limit the number of SMS used by producers
  - Too low cost share amounts would also limit the number of SMS used by producers
- Comparative advantage over other policies (e.g., retirement of irrigated land)

An example: Cost share program implemented by TNC

- 7,000 irrigated acres in the southwest corner of Nebraska
- On every field,
  - soil moisture sensors
  - soil prescription maps
  - pivot telemetry
- irrigation application and yield reported

Changes in revenue

Yield remained the same before and after, meaning revenue stayed the same on average

Changes in cost

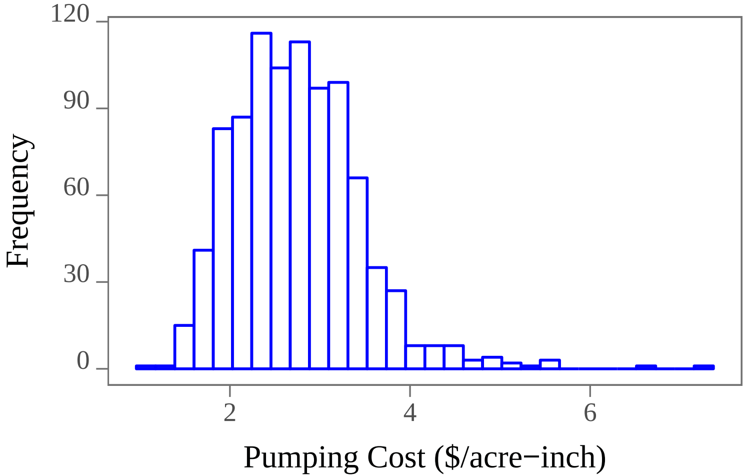
- Irrigation application: 4 inches less $\Rightarrow$ $-4(inches) \times 130(acres) \times 3.8(\$/acre - inch) = -\$1,976$
- Additional annual cost: $\$139$ (wireless service for data transfer) $+ \$250$ (pivot telemetry)
- One-time payment at the beginning (you could also finance them)
  - pivot telemetry: $\$2,000$
  - soil moisture sensor: $\$1,400$ (with wireless access)
  - EC map: $\$1,300$ ($\$10$ per acre)
  - prescription map: $\$300$

Changes in monetary flow by year

change in	2018	2019	2020	2021	2022	total
cost	$5,000+389$	389	389	389	389	$6,645$
revenue	$1,976$	$1,976$	$1,976$	$1,976$	$1,976$	$9,880$
profit	- $3,413$	$1,587$	$1,587$	$1,587$	$1,587$	$2,935$

Recognizing heterogeneity in producers is important

Figure: Pumping cost distribution



Note: unit energy price was assumed to be 0.059 kwh

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revenue	988	988	988	988	988	$4,940$
profit	- $4,401$	599	599	599	599	-$1,696$

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Policy implications

This implies that policy makers may want to target fields with a greater depth to water table instead of indiscriminate cost share opportunities

- Smaller amount of cost share is necessary to induce producers to adopt the system
- Greater numbers of systems adopted by producers (greater amount of water saving)

Important Research Questions

For effective provision of technologies and information, we need to better understand

- how producers use available information
- how various technologies and information complement each other to help producers make effective decisions
- if there is any recognizable pattern in the degree of water saving

An example: What to cost share?

Question:

- What would have happened if only SMS was provided to producers? (How farmers would have irrigated if it were not for pivot telemetry and prescription map?)
  - 3.5 inches of reduction in irrigation?
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- What would have happened if only pivot telemetry and prescription map were provided?
  - 3.5 inches of reduction in irrigation?
  - 0.5 inches of reduction in irrigation?
- What technology and information to provide?
  - SMS only
  - SMS, pivot telemetry, and prescription maps
  - pivot telemetry only

Economics of variable rate irrigation

An example

Optimized computer algorithm (making the best of the available soil moisture and weather information) to generate variable rate irrigation scheduling (when, where, and how much to irrigate) recommendations

- Does the additional water saving compared to a simple uniform irrigation strategy justify the extra cost?
- Most producers won't be able to come up with such irrigation scheduling strategies by themselves (how differently would producers irrigate compared to the optimized strategy?)
- Completely automated (computer-guided) irrigation may help, but beware of the additional investment in infrastructure producers need to make

Who saved water the most (least)?

- Did those who had higher pumping costs decide to reduce irrigation more? If so, it's great because
  - the economic benefit of water use reduction is greater for such producers, meaning less amount of cost share is necessary for them
  - targeting them would achieve a greater amount of water saving under a given budget for cost sharing

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  - combine water use efficiency gap analysis (e.g., Gibson et al 2016) and water use reduction data for statistical analysis
- Any other observable characteristics that affect water use reduction
  - soil
  - weather

Key

Such information allows policy makers to design cost share programs better (a bigger bang for the buck)